Clean the Ocean: An Immersive VR Experience Proposing New Modifications to Go-Go and WiM Techniques

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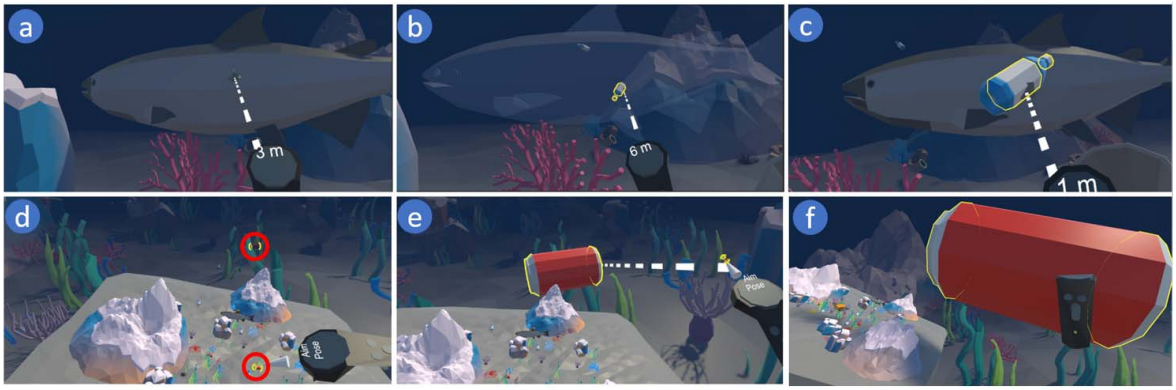

Figure 1: 3DUI solutions proposed in this paper: (a-c) ReX-GoGo, an enhancement to the Go-Go technique with X-Ray vision and relative mapping. Objects between the user's eyes and the GoGo hand will turn transparent with adaptive C/D ratio for selecting occluded targets in a dense environment; (d-f) Rabbit-Out-of-the-Hat (ROH) WiM: an enhancement to the World-in-Miniature technique which allows direct acquisition and manipulation of far-away and occluded 3D objects. Users could summon 3D objects to their hands by pulling their clones outside of the miniature world.

Abstract

In this paper we present our solution to the 2022 3DUI Contest challenge. We aim to provide an immersive VR experience to increase player's awareness of trash pollution in the ocean while improving the current interaction techniques in virtual environments. To achieve these objectives, we adapted two classic interaction techniques, Go-Go and World in Miniature (WiM), to provide an engaging minigame in which the user collects the trash in the ocean. To improve the precision and address occlusion issues in the traditional Go-Go technique we propose ReX Go-Go. We also propose an adaptation to WiM, referred to as Rabbit-Out-of-the-Hat to allow an exocentric interaction for easier object retrieval interaction.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Human-centered computing—Human computer interaction (HCI)—Interaction techniques

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1 Introduction

Interaction techniques and their fidelity play a significant role on the user experience in VR. Traditional interaction styles and techniques may not always lead to a realistic and compelling user experience [1]. While many classic techniques address issues such as long-range interaction or object selection in highly clustered areas [5, 6], improvements can be made to address some of their existing challenges and enhance their precision and ease. For the 2022 3D User Interfaces (3DUI) contest, we created an immersive VR experience with gamification to increase awareness of trash pollution in the ocean. We also propose multiple enhancements to two classic interactions, Go-Go and World in Miniature (WiM). Our novel design combines science fiction with classic and proposed interaction and UI techniques in an aesthetic, easy to learn, and coherent narrative.

2 Design Process

Our design process started with multiple group meetings dedicated to brainstorming ideas for the overarching story. During our bi-weekly meetings, we covered different topics including strategies for addressing the requirements, choice of the classic interaction and UI techniques and our proposed modifications, implementation strategies, story details and modeling. Next, we divided into different groups focusing on art, story, and implementations of interaction techniques. We used an HTC VIVE Pro head-worn display and two HTC VIVE controllers for our implementation and testing. We created the final program under OpenXR framework which allows flexibility in the choice of head-worn display used for the experience.

3 Story and Gameplay

Our story takes place in year 2048, where unexpected mutations in oceanic wildlife have occurred due to their consumption of plastic

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Figure 2: The player uses an experimental submarine's pollutant extracting equipment to clean the trash from the ocean.

wastes polluting the ocean. These mutations have caused certain deep-sea creatures to grow exponentially in size, leading to reports of their aggressive behaviors toward other marine life and investigating parties. Studies have shown that removing particular contaminants will cause insufficient nutritional intake for these creatures and lead to their extinction, preventing their potential long-term food chain effects. The user is cast as a senior marine biologist leveraging an experimental submarine built to withstand these mutant creature threats and equipped to collect large amounts of plastic waste from the ocean (Fig. 2).

The submarine follows an auto-piloted, pre-calculated route, determined to have the most amount of plastic waste. En-route, the user uses the submarine's pollutant extracting equipment to capture contaminants and sorts them in their corresponding disposal units. At the end of the route, the user will be presented information regarding their retrieval and sorting contributions, attributing an overall score for their efforts.

4 Interaction Techniques

The major challenges we aim at addressing with our techniques are target selections in 3D virtual environments. Specifically, we focus on selections and acquisitions of (1) partially or fully occluded targets; (2) targets that are beyond arm-reach distances to the users; (3) targets in a cluttering and dense environment. In an effort to address these challenges and improve the user's experience and capabilities as they work toward the story objective, we investigated and enhanced the egocentric Go-Go interaction technique and the exocentric World in Miniature (WiM) interaction technique [4–6]. The Go-Go technique better facilitates precise object selection in cluttered areas in which WiM is less performant. At greater distances, where more objects intersected by the Go-Go virtual hand are known to impact depth relationship understanding of the objects [7], the WiM technique provides improved object selection.

4.1 ReX Go-Go Technique

To select objects in the immediate vicinity, we propose two enhancements to the traditional Go-Go interaction technique [4], referred to as "RElative-mapping X-ray Go-Go" or "ReX Go-Go". Similar to the traditional Go-Go technique, in our ReX Go-Go once the virtual hand is on an object will be highlighted and the user can grab that object using the trigger on the controller (Fig. 1a & c). However, in ReX Go-Go technique, once the user extends the virtual arm beyond an object, it will become semi-transparent, reducing occlusion issues and accommodating the user to see behind it (Fig. 1b). Inspired by the Depth-Ray [3] and Alpha cursor techniques [7], we implemented this by casting a ray from the player's eye to the virtual hand. Any objects that are within a certain distance to the ray would become transparent, enabling a clear view of the originally occluded objects behind them. However, even with X-Ray vision enabled, it could still be challenging for users to perform precise selections if the target objects are surrounded by undesired decoys, for example when the trashes are entangled by seaweeds. In order to improve the precision of selection in a cluttered area, we also integrated a relative mapping technique to our ReX Go-Go. Inspired by relative mapping and the PRISM technique [2], we dynamically adjust the relative speed of movement between the virtual hand and the controller. Our relative mapping correlates slower movements of the controller to small movements in the virtual hand allowing better control and higher precision in the selection of multiple closely located objects. On the other hand, faster movements of the controller corresponds to similar movements of the virtual hand allowing direct and unconstrained interactions when precise control is not needed.

4.2 Rabbit-Out-of-the-Hat Technique

As WiM provides a scaled viewport of the main scene with equivalent scaled objects, it enhances user's visibility of their environment and empowers them to interact with the objects easily (Fig. 1d). Our technique, referred to as "Rabbit-Out-of-the-Hat" (ROH), offers an enhancement to the traditional WiM technique. In this technique the user can lift any scaled object from the WiM viewport. Once they pull the scaled object out of the viewport, the equivalent main scene object moves towards their hand (Fig. 1d-e), facilitating the trash collection task, creating a pleasant and easy interaction technique.

These two techniques combined serve to circumvent 3D occlusion visualization and precision selection problems in the oceanic environment. As "ReX Go-Go" handles quick and precise object discovery, selection and retrieval, ROH is available to facilitate object retrieval when targets are too far away and beyond reach with the GoGo hands, or when "Superman's X-ray vision" problem occurs due to the existence of too many occluding layers [7].

5 Conclusion

We created a novel immersive VR experience with gamification that leverages egocentric (Go-Go) and excocentric (WiM) interaction techniques with the secondary goal of raising awareness of trash pollution in the ocean. We suggest new adaptations to both techniques and propose ReX Go-Go and ROH to address issue of long-range highly-clustered object selection such as precision and occlusion and facilitate object retrieval interaction.

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